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ABSTRACT

The purpose of the study was to compare two methods of learning multiplication facts in order to develop speed and accuracy. The researcher conducted the action research project with a seventh grade enrichment class, which met for seven weeks during the school year. As part of the curriculum students were provided with activities to refine their basic math skills. The study took place during two weeks in which students practiced the multiplication facts to develop speed and accuracy. The class was divided into two groups with one group receiving paper and pencil practice with "Minute Madness" worksheets (control group), and the other group using the drill and practice software, "Multiplication Puzzles" (treatment group) on the Apple IIe computers. Both groups were given the same pretest, which consisted of sixty single-digit multiplication problems to complete within one minute. The pretest was graded based on the number of correct answers completed out of the sixty problems. Each group received thirty minutes of instruction for eight days during a two-week period. At the end of the period, the students took the same test (posttest) to measure improvement in learning the multiplication facts. The mean scores for the posttests of each group were compared. The results indicated that there was a significant increase in the number of problems correctly completed by the treatment group that used "Multiplication Puzzles" on the computer, whereas mean scores for the pencil and paper group did not indicate a significant improvement in the development of their multiplication skills. (Contains 41 references.) (Author/YDS)

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THE EFFECT OF DRILL AND PRACTICE SOFTWARE ON MULTIPLICATION SKILLS: "MULTIPLICATION PUZZLES" VERSUS *THE MAD MINUTE*

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A Research Project
Presented to the
Department of Teacher Education
of Johnson Bible College

In Partial Fulfillment
of the Requirement for the Degree
Master of Arts in
Educational Technology and Bible

by
Lynda Patterson Williams
April, 2000

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APPROVAL PAGE

This research project by Lynda Patterson Williams is accepted in its present form by the Department of Teacher Education at Johnson Bible College as satisfying the research requirements for the degree Master of Arts in Educational Technology and Bible.

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ON MULTIPLICATION SKILLS:

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Both groups were given the same pretest, which consisted of sixty single-digit multiplication problems to complete within one minute. The pretest was graded based on the number of correct answers completed out of the sixty problems. Each group received thirty minutes of instruction for eight days during a two-week period. At the end of the period, the students took the same test (posttest) to measure improvement in learning the multiplication facts. The mean scores for the posttests of each group were compared. The results indicated that there was a significant increase in the number of problems correctly completed by the treatment group that used "Multiplication Puzzles" on the computer, whereas mean scores for the pencil and paper group did not indicate a significant improvement in the development of their multiplication skills.

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This project is dedicated to my father, John Patterson, who passed away on November 24, 1999. He taught me to be a life-long learner and to pursue my dreams.

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Chapter 1

INTRODUCTION

Significance of the Problem

Some students enter middle school (grades 6-8) lacking the multiplication and computational skills needed for seventh grade mathematical curriculum studies. Because of inadequate skills in automatically and correctly recalling the multiplication facts, students often develop mathematical anxieties and have difficulties in developing mathematical skills during the following years of study (Wittman, et al., 1998, p. 2).

Statement of the Problem

In discussions with middle school math teachers, many believe that students who are unprepared and unsuccessful working with the seventh grade curriculum do not recall the multiplication facts quickly and accurately. Even though students are introduced to this basic skill in the early grades, many of them have not achieved mastery performance levels to the extent that they can swiftly recall the multiplication facts. This study researched how Computer Assisted Instructional (CAI) software could help seventh grade students master the multiplication facts. It compared the results with the conventional paper-pencil method of learning.

Definition of Terms

Computer Assisted Instruction (CAI) Computer applications or programs that are used for instructional purposes are called CAI (Grabe and Grabe, 1998, p. 428).

Characteristics of this mode of learning are derived from programmed instruction using a computer to steer the student through the particular program (Emerson, 1998, p. 46).

Automaticity "The process by which well-learned skills are executed with minimal mental effort" (Grabe & Grabe, 1998, p. 427) is called automaticity.

Computer Based Instruction (CBI) This term is usually understood to be the same as CAI, and in this paper the two will be used synonymously.

Computer Lab In this study this is the classroom within the school building that contains Apple IIe computers. There are approximately thirty working computers, so there will be a sufficient number of computers with the CAI software.

Drill and Practice Computer software that provides an opportunity to acquire a given skill that has been previously taught is called drill and practice. "The drill concerns factual memorization, and the practice concerns the development of skill fluency " (Grabe & Grabe, 1998, pp. 97-98). When teachers refer to using technology to teach basic math skills, what they often have in mind is computerized drill and practice software, which gives sequencing and adjusts the difficulty to the student's response levels (Trotter, 1999).

Mastery "The multiplication facts are mastered when the responses are immediate rather than delayed by intermediate strategies" (Thornton, et al., 1983, p. 238). "Real mastery implies, over time, children consistently exhibit both accuracy and speed with facts" (Thornton, et al., 1983, p. 241). The mastery level for the pretest and posttest will be set in terms of number of problems completed correctly per minute.

Limitations of the Study

The sample pool was small consisting of only one class of seventh-grade students assigned to the researcher for an enrichment course. All students in the class were included in the project although scores for Special Educational students were not included.

The length of time provided in the study was limited to eight days during a two week period. Both the treatment and control group worked for a total of four hours during that time.

The study used CAI software called "Multiplication Puzzles" by Minnesota Educational Computing Corporation (MECC) and was produced in 1985. This older version of CAI software was the only software available to the researcher for helping students practice the multiplication facts on the Apple IIe computers. Even though the Apple IIe computer is older technology, there were enough computers and software disks available for each student in the study so students did not have to share and could go at their own pace.

The test used for the pretest and posttest to determine the level of mastery of the multiplication facts was not a standardized test, but was taken from the highest level of *The Mad Minute* worksheets. The scores were not compared to those of other seventh grade students in the school or nationally.

The Computer Skills teacher was the researcher and worked with the CAI treatment group in the Apple IIe Lab. A certified math teacher administered the paper-pencil *The Mad Minute* worksheets to the control group.

Assumptions

It was assumed that the multiplication math facts had been taught in previous math classes beginning in the third grade, so the drill and practice sessions would reinforce their learning and help students develop automaticity of the multiplication facts rather than provide initial instruction.

Null Hypotheses

The following null hypotheses were tested using a pretest and posttest of the multiplication facts:

1. Students in the CAI group using "Multiplication Puzzles" will have no significant increase in mastering the multiplication facts at the .05 level of significance.

2. Students using pencil-paper with *The Mad Minute* worksheets will have no significant increase in mastering the multiplication facts at the .05 level of significance.

3. Students in the CAI group using "Multiplication Puzzles" will have no significant increase in mastering the multiplication over students receiving an equal amount of classroom practice with pencil-paper using *The Mad Minute* worksheets at the .05 level of significance.

Chapter 2

REVIEW OF RELATED LITERATURE

Historical Perspective of CAI in Mathematics

Research of computer-based drill and practice software for improving mathematical skill development has been investigated since the early eighties when computers first appeared in the classrooms. Many researchers have looked at the effects of CAI upon special groups of students --- learning disabled, mentally handicapped, at-risk, gender, economically deprived, and learning problems due to math anxieties. Varied opinions over the emphasis on conceptual and contextual knowledge of mathematics as opposed to rote and drills have prevailed since the 1989 National Council of Teachers of Mathematics published the Curriculum and Evaluation Standards for School Mathematics (Hiebert, 1999, p. 5). The emphasis in math education has placed less importance on memorizing mathematical facts using drill and practice exercises during the 1990's to the extent that unfavorable attitudes have developed toward using CAI drill and practice software for "regular" students (Trotter, 1999). However recent studies are reporting the improvement of basic math skills when computer-based drill and practice software is used.

Influence of the NCTM Standards on Instructional Practices

The National Council of Teachers of Mathematics (NCTM) promotes excellence in mathematical education. The world's largest mathematics organization provides guidelines and recommendations for instruction and classroom practices. This

organization emphasizes math instruction that provides rich learning opportunities that enable students to excel and achieve math competencies.

The NCTM's *Curriculum and Evaluation Standards for School Mathematics* (1989), *Professional Standards for Teaching Mathematics* (1991), and *Assessment Standards for School Mathematics* (1995) serve as guidelines for classroom teachers to teach excellence in mathematics (NCTM Handbook, 1997-98, p. 4). The NCTM Standards are based on research as well as data collected on students' achievement. The Handbook of Research on Mathematics Teaching and Learning is compiled by the NCTM Center for Research on Teaching and is the basis for the recommendations that the council makes for improving the teaching and learning of mathematics.

Mathematics has changed through the years and the NCTM has reacted to the changes that have taken place in technology, society, and learning theory. "In this new world, we need to redefine the way we prepare our children to understand and use the power of mathematics" (NCTM Handbook 1997-98, p. 4). The NCTM Standards stress the use of technology in the form of calculators, computers, and other tech tools that should be used in mathematics appropriately for contemporary math, but that they should not replace the need to learn to compute mentally or with paper-and-paper-pencil (NCTM Handbook 1997-98, p. 6).

Effects of Technology on Learning

In terms of the actual effects of technology on academic achievement and other educational outcomes, advocates assert that most uses of technology are beneficial and can lead to educational improvements. The use of CAI has been evaluated repeatedly,

and the evaluations suggest that CAI students demonstrate higher levels of academic achievement than their counterparts who do not have CAI (Wenglinsky, 1999). Seymour Papert, of MIT Math Department as Editorial Chairman of the Journal Of Computers For Mathematical Learning states:

> The nature of learning and teaching mathematics has scarcely changed from the days of Euclid. The entry routes to mathematics, the kinds of activities open to a beginner, the kinds of teacher-learner and learner-learner interaction available in the classroom, were all shaped by the technology of paper-and-pencil and a compatible pedagogy which relied heavily on lecturing, practicing, and testing. With the development of innovative computational environments, driven by new visions for teaching and learning mathematics, radically new approaches are emerging (Papert, 1999).

Schiefele explains that students' experiences in the math classroom are linked significantly to interest, and that interest often predicts student achievement in mathematics. To increase student interest in math, standard mathematics instruction through lectures and seat work needs to be supplemented with more active and student-involved activities, such as the use of computers (Schiefele & Csikszentmihalyi, 1995, pp. 164-65).

In reviewing recent studies, there seems to be different results. There are variations in academic achievement and other outcomes between students exposed to CAI and those exposed to conventional teaching techniques. Some findings indicate that differences vary dramatically depending upon study methodology, with some studies finding no difference or even a negative relationship. Studies by Kulik & Kulik (1991), Liao (1992), and Christmann, Badgett & Lucking (1997) are recognized as showing gains in learning when using CAI software.

Developmental Sequencing of Multiplication Instruction

Developing multiplication skills involves three phases of instruction: conceptualization, fact learning, and algorithms. "Conceptualization involves the instructional aspect where a child constructs a mental image of an operation" (Thornton, et al., 1983, p. 271). Understanding the concept of multiplication should precede memorization. From the conceptual stage, the student proceeds to fact learning in which organization of relationships and patterns is emphasized. In this stage students "need to achieve immediate recall of all basic multiplication facts" by using models and physical aids (Thornton, et al., 1983, p. 272). Motivational activities as well as drill and practice strategies are beneficial to students trying to master the multiplication facts. During the third phase of mastering the multiplication facts, the instruction is directed to associated algorithms. An algorithm is a precise, systematic method for solving a class of problems" (Morrow, 1998, p. 21). There are computer programs that can engage students in motivational practice settings and help them understand how algorithms work (Morrow, 1998, p. 4).

Effect of Learning Styles in Mathematics Education

A wide range of learning situations and experiences is valuable in guiding and instructing students through each stage of learning the multiplication facts because children do not learn the same way. The author of Making Multiplication Easy simplifies the different aspects of learning by stating:

> Some are visual learners; what they *see* is what they get. Others are auditory learners; what they *hear* is what they get. And still others are

> kinesthetic learners; what they *handle* is what they get (Goldish, 1991, p. 4).

Understanding how students learn and how the brain works is important in guiding the instructional process as students develop mathematical skills. According to the NCTM *Standards*:

> Students in middle school are at a critical stage when the attitude they develop toward mathematics can have a significant impact on the chances for success in high school mathematics and on the life choices. It is therefore essential that mathematics teaching in the middle grades help students experience mathematics as a personally meaningful and worthwhile endeavor. Furthermore students should see mathematics as a powerful and useful tool in their lives, in their pursuit of knowledge in other subject areas, and in their careers (NCTM Handbook, 1997-98, pp. 30-31).

Conclusion

This researcher has noted in reviewing literature pertaining to developing and mastering the multiplication skills that this topic has been studied for many years. However, one tried-and-true method of instruction has not been determined. There seems to be a return to teaching rote memory as a means of learning the multiplication facts as well as using meaningful tasks to understand the conceptual aspect of mathematics.

Since the advent of computer technology in the classroom, many types of software have been developed to teach mathematical skills. Drill and practice software, which helps students to master the multiplication facts, seems to be a valuable resource as well as the conventional methods for helping students develop automaticity with the multiplication facts.

Chapter 3

METHODS AND PROCEDURES

Experimental Method

Seventh grade students attending an enrichment class were divided into two groups. One half of the group worked with the researcher in the Apple IIe Computer Lab, and the other half worked with a certified math teacher. The treatment group used CAI software, "Multiplication Puzzles" (MECC, 1985). The control group used *The Mad Minute* worksheets. Each group received the same time allotment during the study. The students were tested at the beginning of the study and again at the end of the study to determine their mastery of multiplication facts. The pretest and posttest scores were compared to determine the improvement of each group. Statistical analysis was used to compare mean scores between the two samples to determine the effect of the treatment on learning the multiplication facts. After practicing the multiplication facts each day, both groups were rewarded with computer time and allowed to use educational software.

Selection of Subjects

The subject pool consisted of a class of seventh grade students (ages 12-13) attending a middle school in Eastern Tennessee. The school population was composed of rural and urban students with 43% of the students qualifying for the free or reduced lunch programs according to the federal government guidelines. The study involved students from a homeroom who attended the researcher's enrichment class held in the computer lab. The sample pool was a heterogeneous mixture of students and was not selected based

on gender, race, mathematical abilities, or computer skills. All students within the class participated in the study, but Special Educational students were not included in the statistics.

To divide the subject pool, the class roll was arranged alphabetically and numerically ordered. The odd-numbered students were assigned to the Apple IIe Computer Lab (treatment group), and the even-numbered students were assigned to the conventional paper-pencil class (control group).

Timeline of Study

Both groups worked for eight days during a two-week period and received the same amount of time for drill and practice of the multiplication facts. The subjects received thirty minutes of drill and practice during each class session for a total of four hours.

First Week:. All students were given a written pretest on the multiplication facts. The class was divided into two groups with one half of the group assigned to the researcher in the Apple IIe Computer Lab (treatment group) and the other half assigned to a certified math teacher in another computer lab (control group).

Next 2 weeks: Each class worked for thirty minutes on multiplication facts for eight days during a 2-week period. This schedule provided students with four hours of additional drill and practice time to help them develop mastery of the multiplication facts.

Week 3: The multiplication posttest was administered to the treatment and the control groups. The test was the same as the pretest and the same procedures were followed in administering the test.

Conclusion: Scores were tabulated and statistically analyzed to compare the improvements of each group.

Pretest and Posttest

A written pretest was administered to the two groups during the first week of class. The test included math problems using multiplication facts from zero to ten and was timed. The test was taken from the highest level (Level F) in *The Mad Minute* workbook. Students were given sixty multiplication facts to work in one minute. The test was scored based on the number of correct answers attained. At the end of the study, the two groups took the same test again. The posttest scores served as the basis for measuring changes and improvements in learning the multiplication facts.

Experimental Factor

The experimental factor of this study was the use of the CAI software, "Multiplication Puzzles," to practice the multiplication facts for attaining competency and 80% mastery level. The treatment group used the Apple IIe computers.

The control group used *The Mad Minute* worksheet series, which is a conventional paper-pencil method of practicing the multiplication facts.

Both groups were rewarded each day with computer time using educational software of their choice after practicing the multiplication facts for thirty minutes.

Software and Hardware

The Computer Lab for the treatment group contained Apple IIe computers. There were enough computers in the lab so that each student in the study had the use of a computer and did not have to share or get distracted by a partner. The treatment group

used the CAI software, "Multiplication Puzzles" from Minnesota Educational Computing Corporation (MECC, 1985). The school had a working copy for each computer. The software presented drill and practice problems on whole number multiplication. After completing twenty-five problems, the student was rewarded with a brief game if mastery of 80% was achieved for the group of problems. The software kept a record of each student's performance, and the computer teacher (researcher) was able to check the mastery level attained through the management options. The manual states:

> "Multiplication Puzzles" presents drills that reinforce and reward correct calculation of problems with an opportunity to play games that emphasize logic and problem solving skills. The programs are sequenced on the diskette according to the level of difficulty. The package keeps records of individual student performance, which are accessible through a Management Option (MECC, p. 7).

Statistical Analysis

All students in the study were given a paper-pencil pretest consisting of a series of problems in multiplication facts from zero to ten. This test was a timed test to determine accuracy response rates for the multiplication facts. The scores were recorded for each student and the t-test was calculated on the raw data using the .05 level.

At the conclusion of the drill and practice time allotment, the same testing instrument was used for the posttest. The results were compared using statistical analysis software to determine if there was any significant improvement in mastering the multiplication facts for the CAI treatment group and the paper-pencil control group. The mean increase in the skill level for the CAI treatment was compared to the mean increase in the control group that used the paper-pencil worksheets.

Chapter 4

RESULTS

The purpose of this study was to investigate two methods of instruction that are available to students as they learn the multiplication facts. The methods used by the researcher were pencil-paper instruction and Computer Assisted Instruction (CAI). The researcher tested each of the null hypotheses by collecting data from the pretest and posttest scores for each group and comparing the mean scores using a t test analysis. The results were as follows:

Computer Assisted Instruction: "Multiplication Puzzles"

There were fourteen students in the CAI group which used the computer software, "Multiplication Puzzles" to practice the multiplication facts. The same test was used for the pretest and posttest and contained sixty single-digit multiplication problems. Students were given one minute to work as many problems as possible. Both tests were scored based on the number of correct answers attained with sixty being a perfect score. The mean score for the pretest was 35.714 and the mean score for the posttest was 43.857 (See Table 1). The mean difference was -8.143 and the standard error difference was 4.234. The CAI group pretest and posttest mean scores were compared after the treatment, and the t-ratio of -1.923 was obtained.

Hypothesis 1 stated that students in the CAI group using "Multiplication Puzzles" would have no significant increase in mastering the multiplication facts at the .05 level of significance. In the statistical analysis the t-test for Equality of Means indicated that the results of the 2-tailed significance was .065. Therefore there was no significant difference in the treatment of the CAI group. This hypothesis was retained at the .05 level of significance.

TABLE 1

Comparison of Pretest and Posttest Mean Scores
Treatment Group using CAI
"Multiplication Puzzles"

Group	**N**	**Mean**	**Mean Difference**	**Std.Error of Means**	**t ratio**	**Sig. 2-tailed**
Pretest	14	35.714				
			-8.143	4.234	-1.923	0.065*
Posttest	14	43.857				

*Not Significant

Pencil Paper Group - *Mad Minute* Worksheets

The number of students in the paper-pencil group using *Mad Minute* Worksheets was twelve. The pretest and posttest were identical and contained sixty single-digit multiplication problems. Students were given one minute to work as many problems as possible. Both tests were scored based on the number of correct answers attained with

sixty being a perfect score. The mean score for the pretest was 24.50. After the treatment, the posttest was administered, and the mean score was 23.25 (See Table 2). The mean difference was 1.25 with a standard error of difference of 3.41. The mean scores were compared and the t-ratio of .367 was obtained. The significance of the 2-tailed t-test for Equality of Means was calculated to be .717. Therefore, the null hypothesis stating that students using pencil-paper with *The Mad Minute* worksheets would have no significant increase in mastering the multiplication facts at the .05 level of significance was retained.

TABLE 2

Comparison of Pretest and Posttest Mean Scores
Paper-Pencil Control Group
Mad Minute Worksheets

Group	**N**	**Mean**	**Mean Difference**	**Std. Error of Means**	**t ratio**	**Sig. 2-tailed**
Pretest	12	24.50				
			1.25	3.41	.367	.717 *
Posttest	12	23.25				

* Not Significant

Comparison Pencil-Paper and CAI Groups

The pretest and posttest for both groups consisted of sixty problems. The tests were scored based on the number of correct answers attained with sixty being a perfect

score. The difference between the pretest and posttest scores was calculated for each group to determine the improvement factor. The mean score for improvement of the control group (pencil-paper) was –3.250, and the mean score for improvement of the treatment group (CAI) was 8.1429. (See Table 3 and Figure 1 in the Appendix.) The standard error of difference was calculated to be 3.713. The t ratio was 3.068. The level of significance between the control group (pencil-paper) and the treatment group (CAI) was calculated to be .005. Hypothesis 3 stated that students in the CAI group using "Multiplication Puzzles" will have no significant increase in mastering the multiplication facts over students receiving an equal amount of classroom practice with pencil-paper using *The Mad Minute* worksheets at the .05 level of significance. With the significance being less than .05, the hypothesis was rejected.

TABLE 3

Comparison of Mean Scores of Paper and Pencil and CAI
Mad Minute versus "Multiplication Puzzles"

Group	N	Mean	Mean Difference	Std. Error of Means	t ratio	Sig. 2-tailed
Control	12	-3.250				
			-11.392	3.713	3.068	.005 *
Treatment	14	8.142				

*Significant <.05

Analysis of Covariance

Because the mean scores for the pretests were significantly different before the treatment began, it was necessary to run an analysis of covariance on the data to verify the results as previously discussed. The mean scores using the analysis of covariance was 23.25 for the pencil and paper group (control) and 43.86 for the CAI group (treatment) with a mean difference of 20.61. The standard error of means was 3.79. The *t*-ratio was 5.442 with the significance of the 2-tailed test being .000. Therefore the results of the analysis of covariance confirmed the results of the *t*-test showing a significant gain with the CAI treatment group over the pencil-paper group. (See Table 4 below.)

TABLE 4

Analysis of Covariance

Group	N	Mean	Mean Difference	Std. Error of Means	t ratio	Sig. 2-tailed
Control	12	23.25				
			20.61	3.79	5.442	.000*
Treatment	14	43.86				

*Significant <.05

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The researcher conducted the research project with a seventh grade enrichment class, which met for seven weeks during the school year. As part of the curriculum students were provided with activities and opportunities to refine their basic math skills. The study took place during two weeks in which students practiced the multiplication facts to develop speed and accuracy. The class was divided into two groups with one group receiving paper and pencil practice (control group), and the other group using the Apple IIe computers with drill and practice software (treatment group).

Both groups were given the same pretest, which consisted of sixty single-digit problems to complete within one minute. The pretest was graded based on the number of correct answers completed out of the sixty problems. Each group received thirty minutes of instruction for eight days during a two week period. At the end of the period, the students took the same test (posttest) to measure improvement in learning the multiplication facts.

Conclusions

Both groups were rewarded after practicing the multiplication problems with computer activities related to basic math skills. This served as an incentive for both groups to work on learning and improving their math skills. However, it seemed that the students in the treatment (CAI) group enjoyed working on the multiplication facts and did

not complain. The researcher observed that the students in the control group became disinterested in trying to improve their math skills and just went through the process of doing the problems without trying to improve. This may be an indication as to why the treatment group (CAI) using the computers did better than the control group (paper-pencil).

Recommendations

The researcher recommends that students be given the opportunity to use the drill and practice software programs on the computer to help them learn the basic math skills. The computer programs tend to hold their interest and help them enjoy learning.

The researcher also recommends the use of using other software packages and sites on the Internet that provide opportunities for the students to practice the multiplication facts to become more accurate and to develop speed in recalling the facts. Using a combination of the methods --- computer and pencil-paper --- may also bring greater results than just one method. This was not tested in this research, but could be studied further with other classes.

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APPENDICES

Permission to Participate in a Study

I give permission for my child, _____ to participate in a research study conducted by Lynda Williams to learn the benefits of using Drill and Practice computer software to improve multiplication skills. I understand that my child will not be identified in the research paper in any way. I understand that my child may or may not be using the software as a part of the study, but if the software proves to be beneficial, he or she will have access to it after the study is completed.

_____ _____

Parent Signature Date

KNOX COUNTY SCHOOLS
ANDREW JOHNSON BUILDING

Dr. Charles Q. Lindsey, Superintendent

October 29, 1999

Ms. Lynda Williams
232 Southridge Road
Knoxville, Tennessee 37920

Dear Ms. Williams:

You are granted permission to contact appropriate building-level administrators concerning the conduct of your proposed research study entitled, "The Effect of Drill and Practice Software on Multiplication Skills: 'Multiplication Puzzles' versus 'Mad Minute'." In the Knox County schools final approval of any research study is contingent upon acceptance by the principal(s) at the site(s) where the study will be conducted.

In all research studies names of individuals, groups, or schools may not appear in the text of the study unless *specific* permission has been granted through this office. The principal researcher is required to furnish this office with one copy of the completed research document.

Good luck with your study. Do not hesitate to contact me if you need further assistance or clarification.

Yours truly,

Samuel E. Bratton, Jr.

Samuel E. Bratton, Jr., Ed.D.
Coordinator of Research and Evaluation
Phone: (423) 594-1740
Fax: (423) 594-1709

Project No. 015

P.O. Box 2188 • 912 South Gay Street • Knoxville, Tennessee 37901-2188 • Telephone (423) 594-1800

FIGURE 1

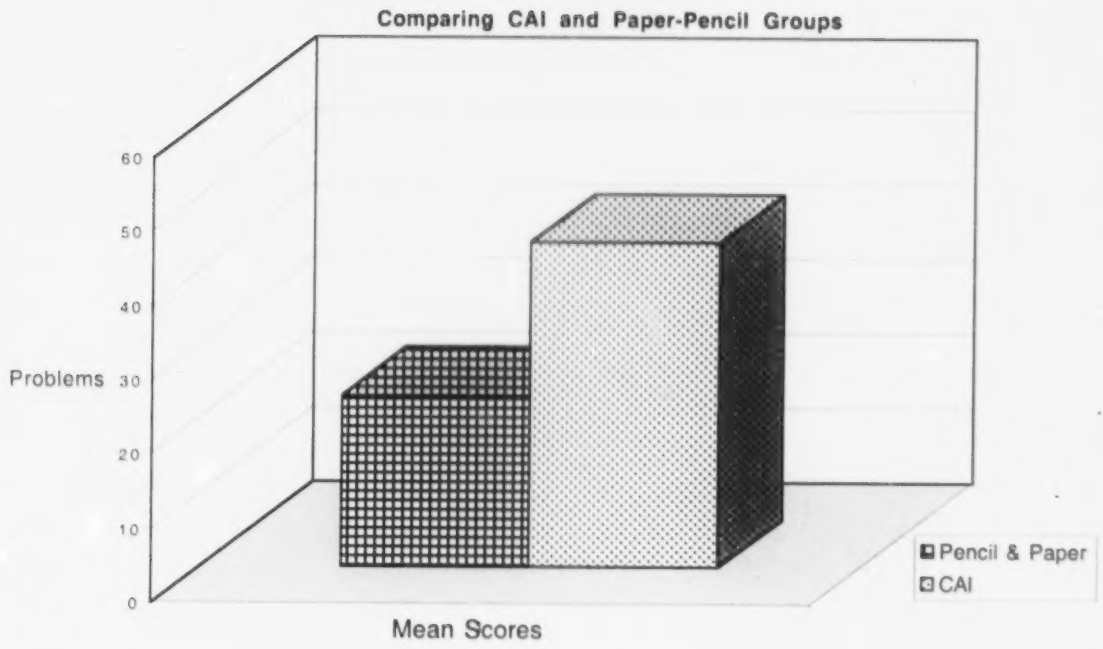

Comparing CAI and Paper-Pencil Groups
60
50
40
Problems 30
20
10
0
Mean Scores
Pencil & Paper
CAI

FIGURE 2

Pretest and Posttest Comparison of *The Mad Minutes* Group

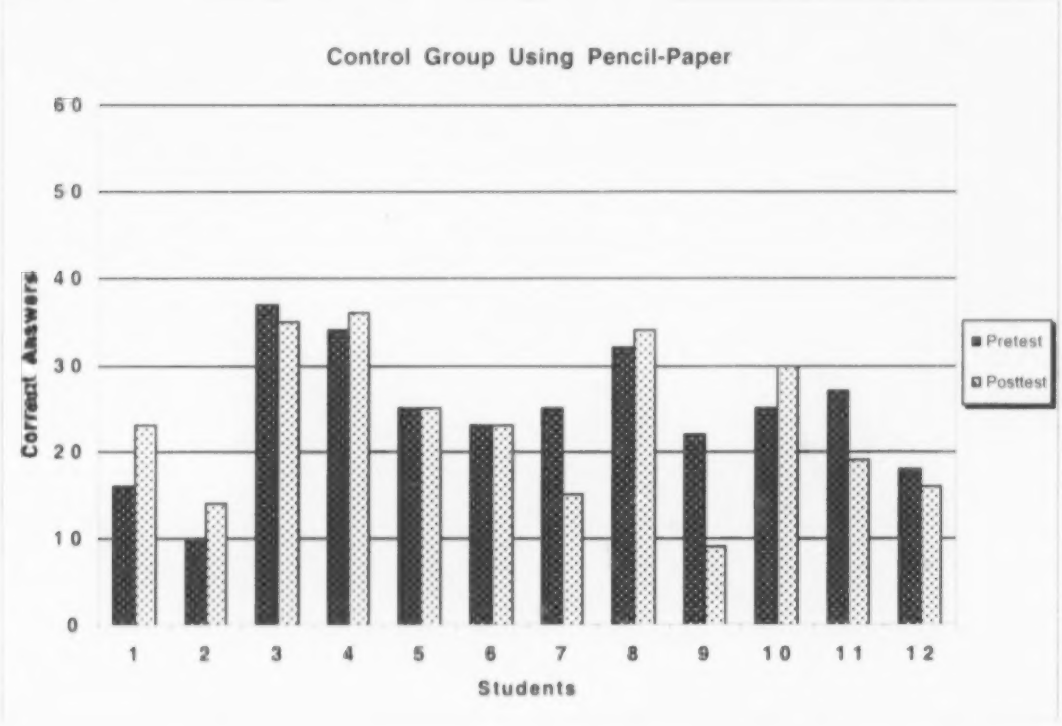
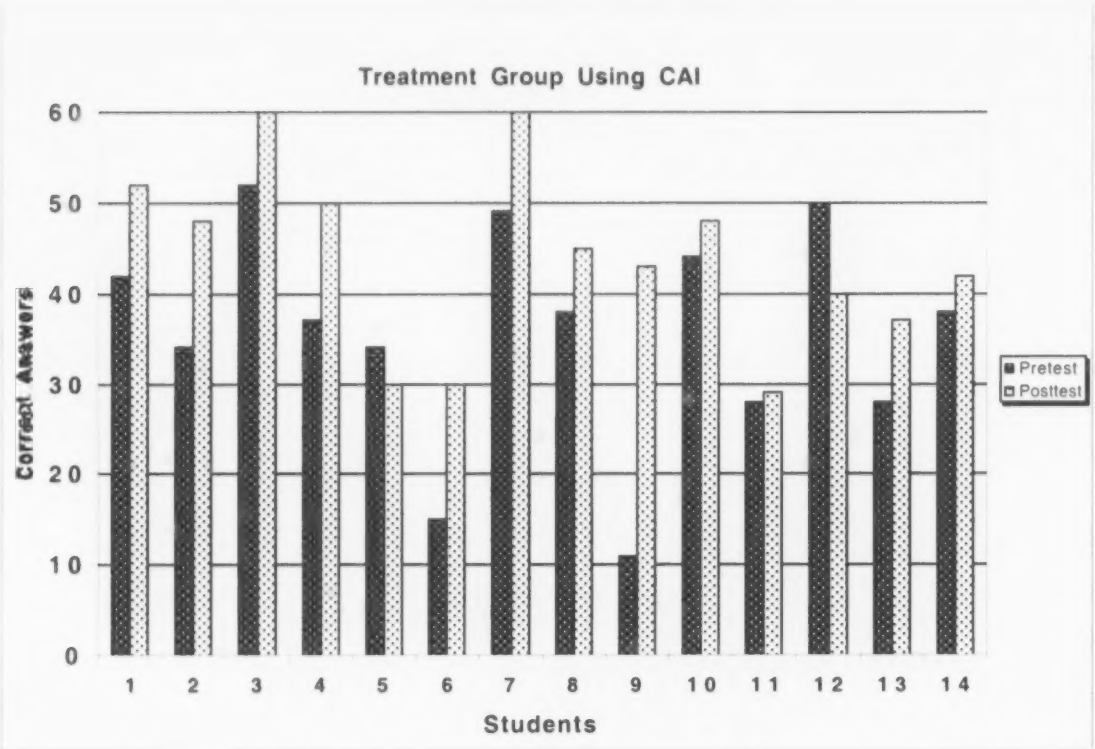


FIGURE 3

Pretest and Posttest Comparison of the "Multiplication Puzzles" Group



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